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EFFECT OF FIN CANT AND NOSE SHAPES ON FREE SPIN OF BASIC FINNER (U)

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U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

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NAVORD Report 6025

Aeroballistic Research Report 26

EFFECT OF FIN CANT AND NOSE SHAPES ON FREE SPIN OF BASIC FINNER

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ABSTRACT: This report contains the results of a wind-tunnel test to determine the free-spin characteristics of the Basic Finner at subsonic and supersonic speeds. The angle of attack was varied from zero to ninety degrees. Fin-cant angles of two, four, and six degrees and seven different nose configurations were tested.

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This investigation was performed at the request of the Bureau of Ordnance (reference (a)) and was performed under task number 803-767/73003/01040.

This report covers only a small portion of the studies being made of the rolling performance of fin-stabilized missiles. Other reports dealing with rolling performance are given in references (b), (c), (d), (e), (f) and (g).

MELL A. PETERSON
Captain, USN
Commander

R. KENNETH LOBB
By direction

CONTENTS

ILLUSTRATIONS

EFFECT OF FIN CANT AND NOSE SHAPES ON FREE SPIN OF BASIC FINNER

INTRODUCTION

1. The Basic Finner is a research shape for many of the aerodynamics coefficient data obtained at the Naval Ordnance Laboratory. This shape is used for calibrating new instrumentation in the wind tunnel and for special research projects.

2. Occasional drops of the Low-Drag Bomb exhibited erratic flight. Studies of this erratic behavior led to a research program on the rolling motion of fin-stabilized missiles at the Naval Ordnance Laboratory, Bureau of Standards, and the University of Notre Dame. Four roll problems were discovered which are roll slow-down, roll speed-up, roll reversal, and roll-lock-in. References (b) through (f) discuss these roll problems.

3. This report presents the roll performance of the Basic Finner at subsonic and supersonic speeds. Previously presented data were for Mach numbers 0.25 or below (reference (g)).

4. The angle of attack was varied from zero to 90 degrees and seven shapes were investigated on a limited basis.

Symbols

M - Mach number
q - Dynamic pressure (psi)
v - Free-stream velocity (ft/sec)
p - Spin rate (rev/sec)
α - Angle of attack (degrees)
L - Missile length (in.)
D - Missile diameter (in.)

Configuration Symbols

N - Nose
T - Tail

Discussion

5. The Basic Finner model shown in Figure 1 has an L/D of 10 and a conical nose with a total angle of 20 degrees. Fin cants of two, four, and six degrees and six nose shapes in addition to the basic nose shape were investigated.

6. Data at Mach numbers of 0.12 and 0.23 were taken in the subsonic wind tunnel at the Bureau of Standards. All other data and a repeat of Mach number 0.23 were obtained at the Naval Ordnance Laboratory.

Procedure

7. A Basic Finner model with a diameter of 1.250 inches was used for this test. The model had fins which were canted as shown in Figure 2. Tails with fin-cant angles of two, four, and six degrees are designated as T_2, T_4, and T_6 respectively. The seven variations of nose shape and designations are given in Figure 3.

8. The model which was free to rotate about its longitudinal axis was supported on two precision ball-bearings along the longitudinal axis. One bearing was in the nose and the other near the center of pressure of the model. As the air passed over the canted fins the forces caused the model to assume a constant spin for each angle of attack and air speed.

Instrumentation

9. The spin rate was recorded in the following fashion. A permanent magnet was mounted on the balance shaft and a distributor wheel was made an integral part of the model. The spinning of the model produced a square wave signal. This signal was spot checked intermittently with a Hewleth-Packard Electronic Tachometer. Additional spot checks were made with a Strobotac and Strobolux. The spin rate was recorded for each five degree increment of angle of attack.

Results

10. Figures 4, 5, and 6 show the roll characteristics of the Basic Finner from Mach number 0.12 to 2.48 over an angle of attack range from zero to 90 degrees. Figure 7 is a cross plot of Figures 4, 5, and 6 at an angle of attack of 70 degrees. The results shown in the three figures are presented in a non-dimensional form in Figure 8. These figures show a strong Mach number effect on the roll performance. At supersonic speeds the model steadily decreases in spin rate and stops spinning at about 65 degrees (4-degree fin cant). Some other preliminary tests were made over a Mach number range from 1.75 to 3.24 and a similar basic behavior was observed.

11. Limited data were taken at a Mach number of 0.52 using the seven nose shapes in order to evaluate the effect of nose shape on roll performance. The model with N_1 had an L/D of 7.4 as compared to an L/D of 10 for the remaining models. Data for noses N_1, N_2, and N_7 are plotted in Figure 9. Data for nose configurations N_2 through N_7 fall on the plot between N_2 and N_7 and were not plotted. Changing the length of the model had a greater effect on the roll performance than did changing the nose shape.

12. The effect of fin cant is shown in Figure 10. Except for displacing the curves the fin cant had only negligible effect on the general characteristics of the curves.

CONCLUSIONS

13. An analysis is not included in the report. A summary report on the roll data obtained at the Naval Ordnance Laboratory, The National Bureau of Standards, and the University of Notre Dame will be issued.

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(a) BuOrd ltr Re03:JDN:dl X11 of 27 Jul 57 to NOL
(b) Nicolaides, J. D., "On the Flight of Ballistic Missiles", (Conf.) Ballistic Technical Note Number 1, 13 Feb 1956
(c) Nicolaides, J. D., "An Hypothesis for Catastrophic Yaw," Ballistic Technical Note 18, 1955
(d) Nicolaides, J. D., and Griffin, T. F., "On a Fluid Mechanism for Roll Lock-In and Rolling Speed-Up Due to Angle of Attack of Cruciform Configuration", Ballistic Technical Note 16, BuOrd, 1955
(e) Nicolaides, J. D., "On the Rolling Motion of Missiles", Ballistic Technical Note 33 (Conf.) 7 March 1957
(f) "Proceedings of the Fourth U. S. Navy Symposium on Aeroballistics Sponsored by The Bureau of Ordnance", NAVORD Report 5904 (Conf.) 1 May 1958
(g) Heald, R. H., Crouch, H., and Adams, G. H., "An Investigation of the Rotational Characteristics of 2-inch and 3/4-inch Diameter Models and a Free-Standing Fin System of the Navy Basic Finner Missile", National Bureau of Standards Report No. 5156 (Conf.) 1957

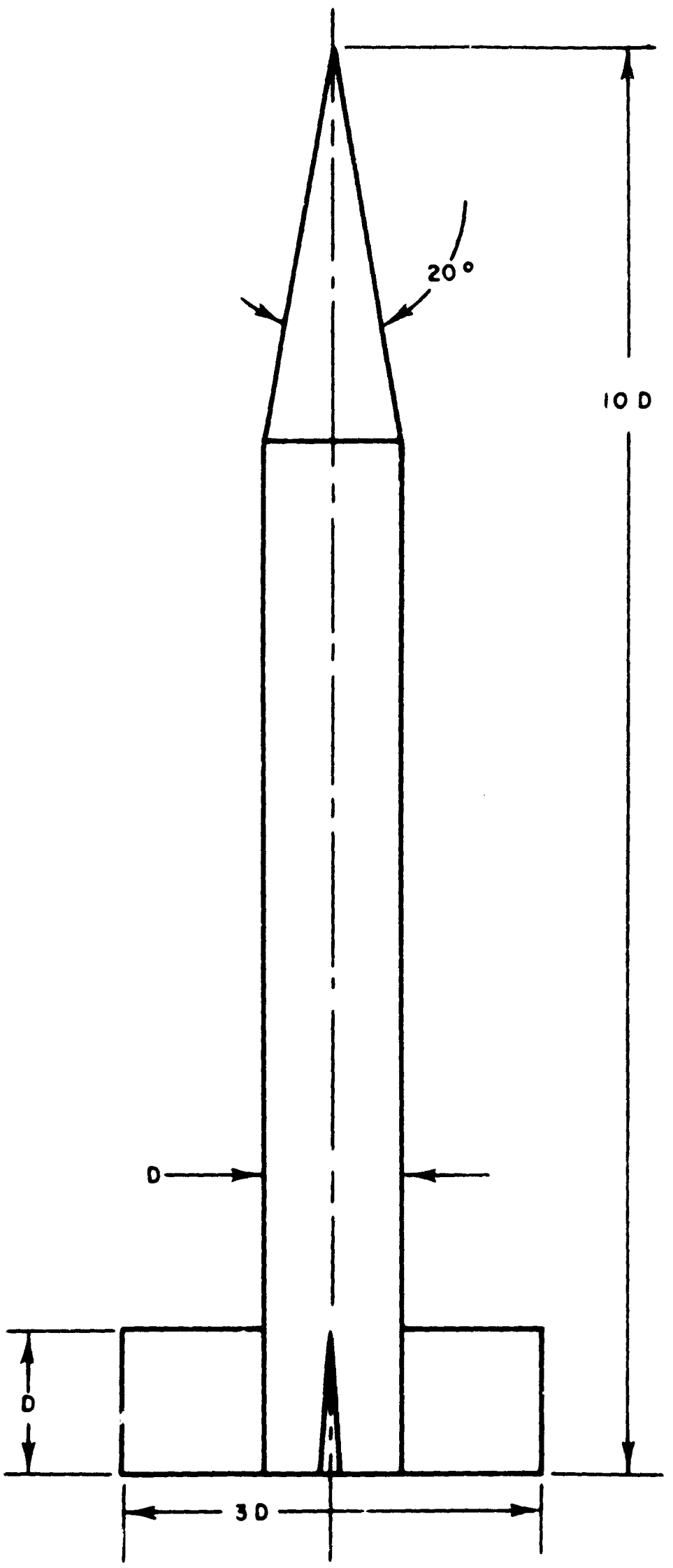

FIG. 1 BASIC FINNER

β = ANGLE OF CANT

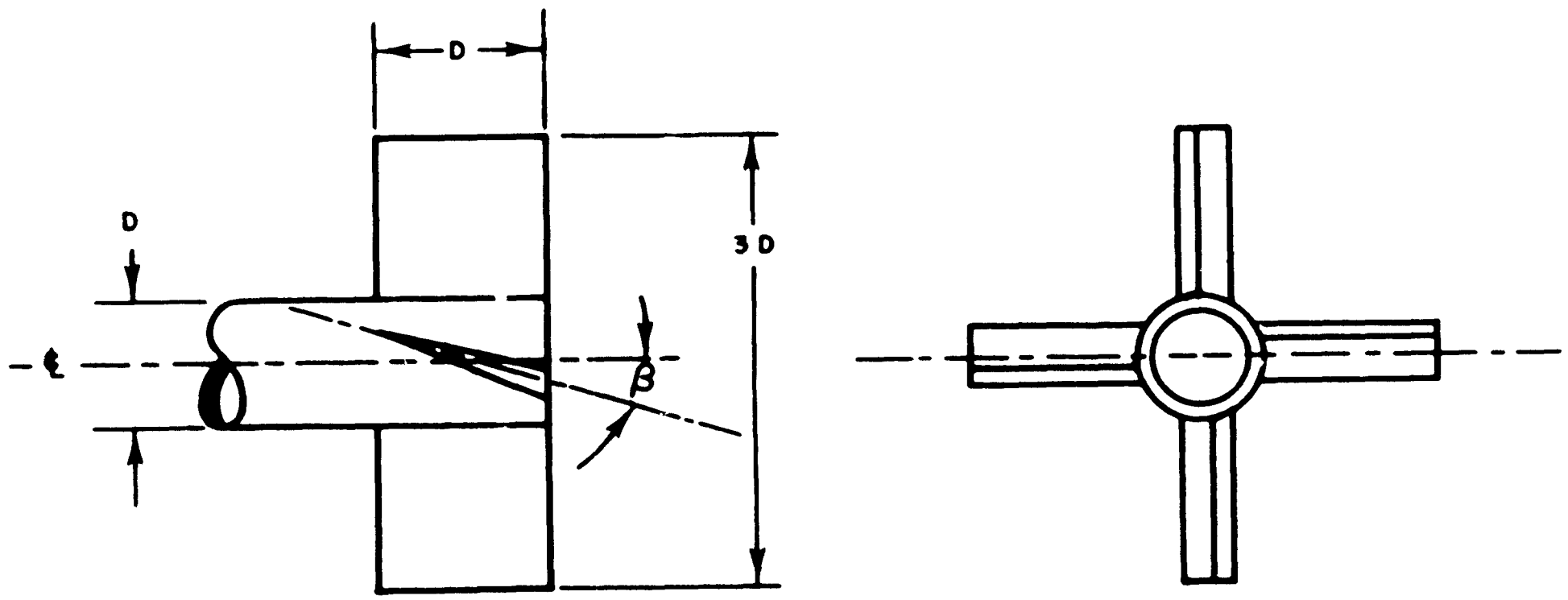

FIG. 2 DETAIL OF CANTED FIN

UNIT NO.	CONFIGURATION NAME
1.	SHORT FLAT
2.	LONG FLAT
3.	SPHERICAL
4.	SECANT
5.	TANGENT
6.	BLUNT CONE
7.	POINTED CONE (BASIC)

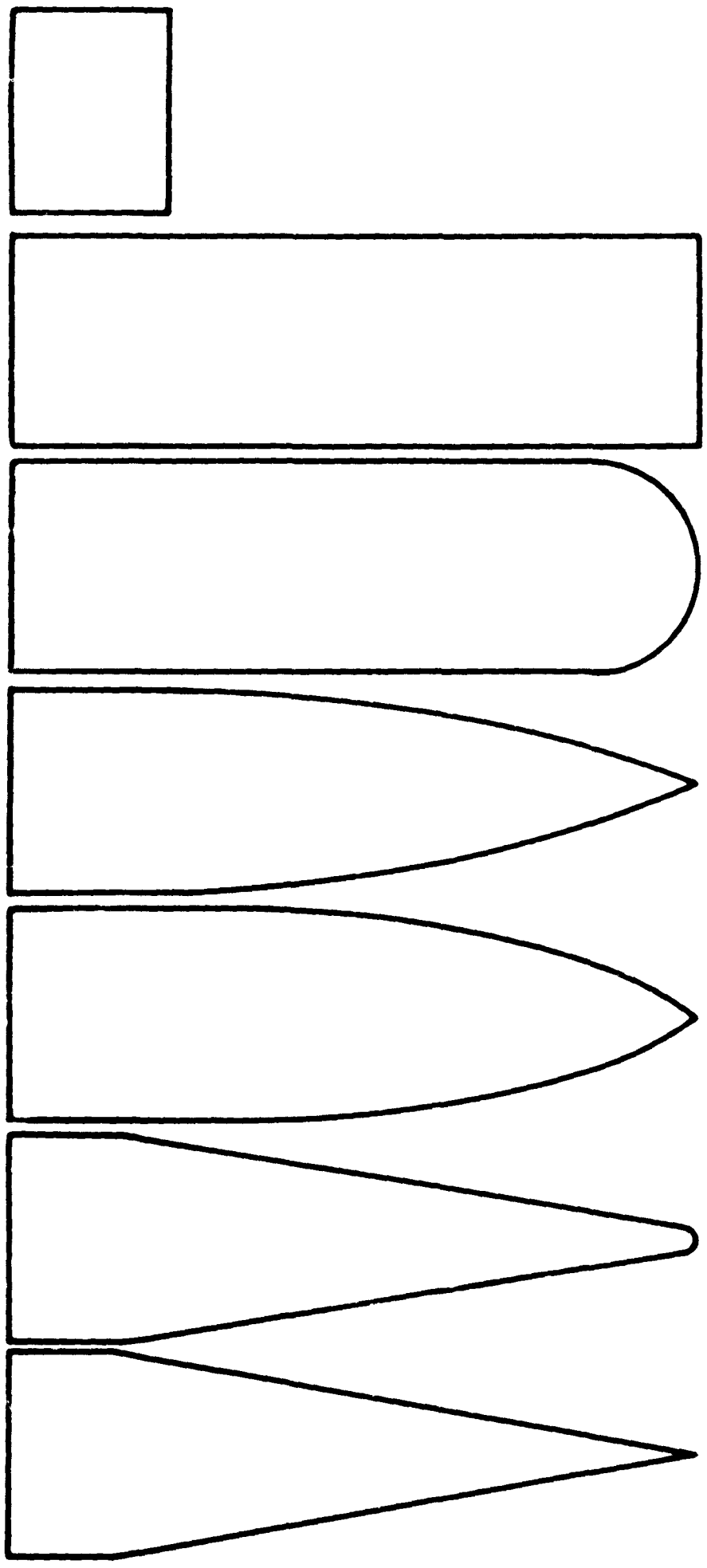

FIG. 3 FINNER NOSE SHAPES

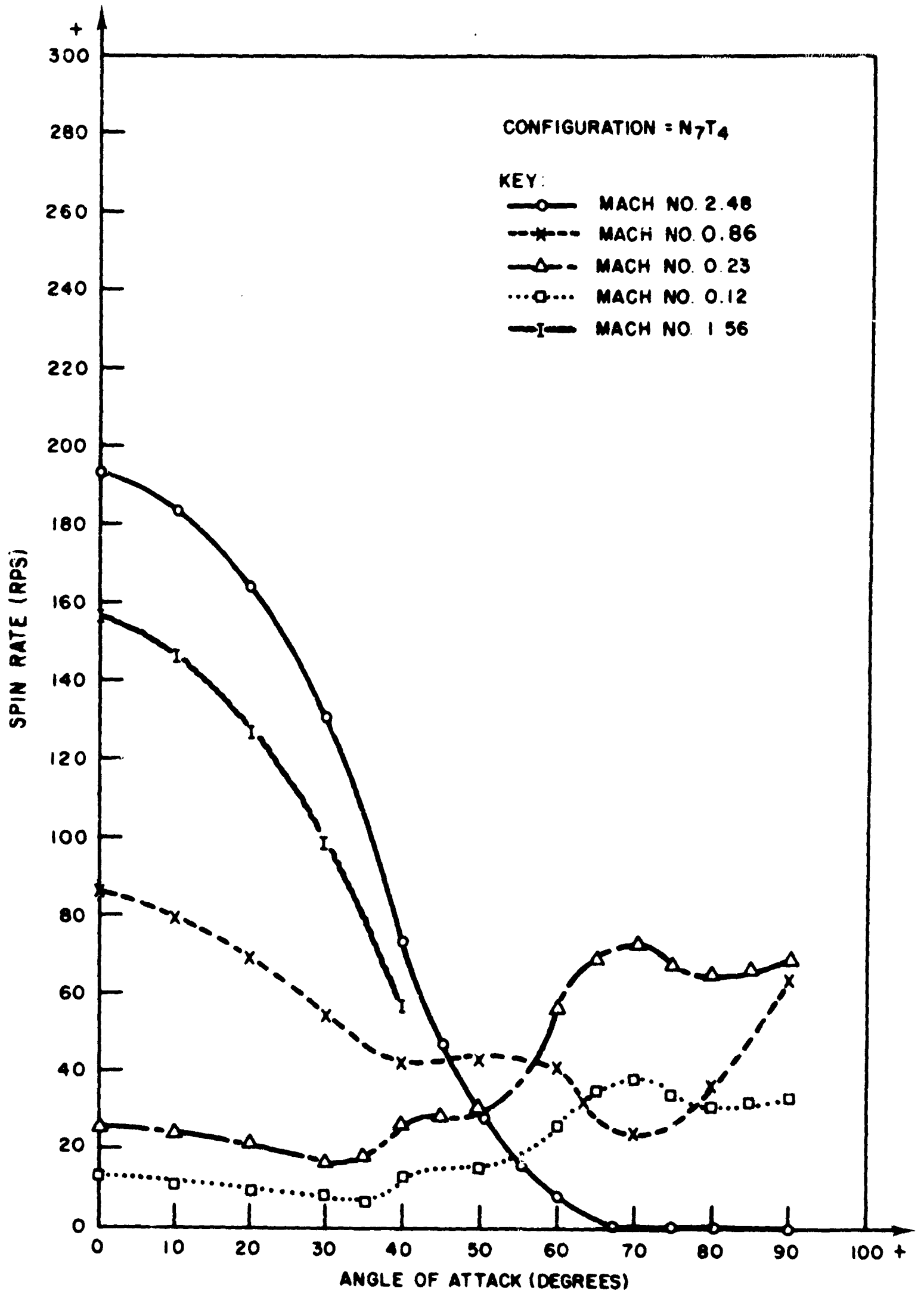

FIG. 4 BASIC FINNER
SPIN RATE VS ANGLE OF ATTACK

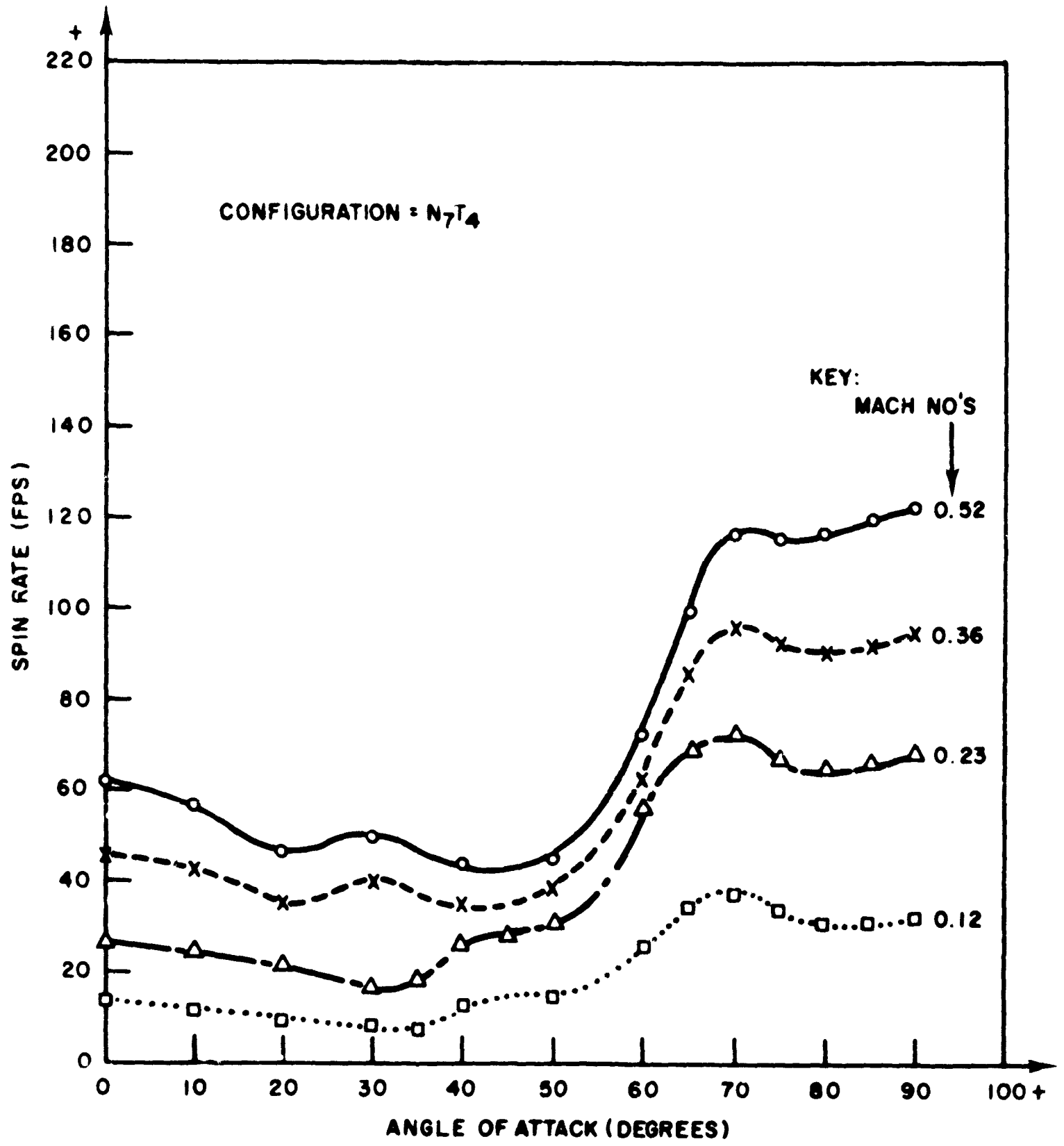

FIG. 5 BASIC FINNER
SPIN RATE VS ANGLE OF ATTACK

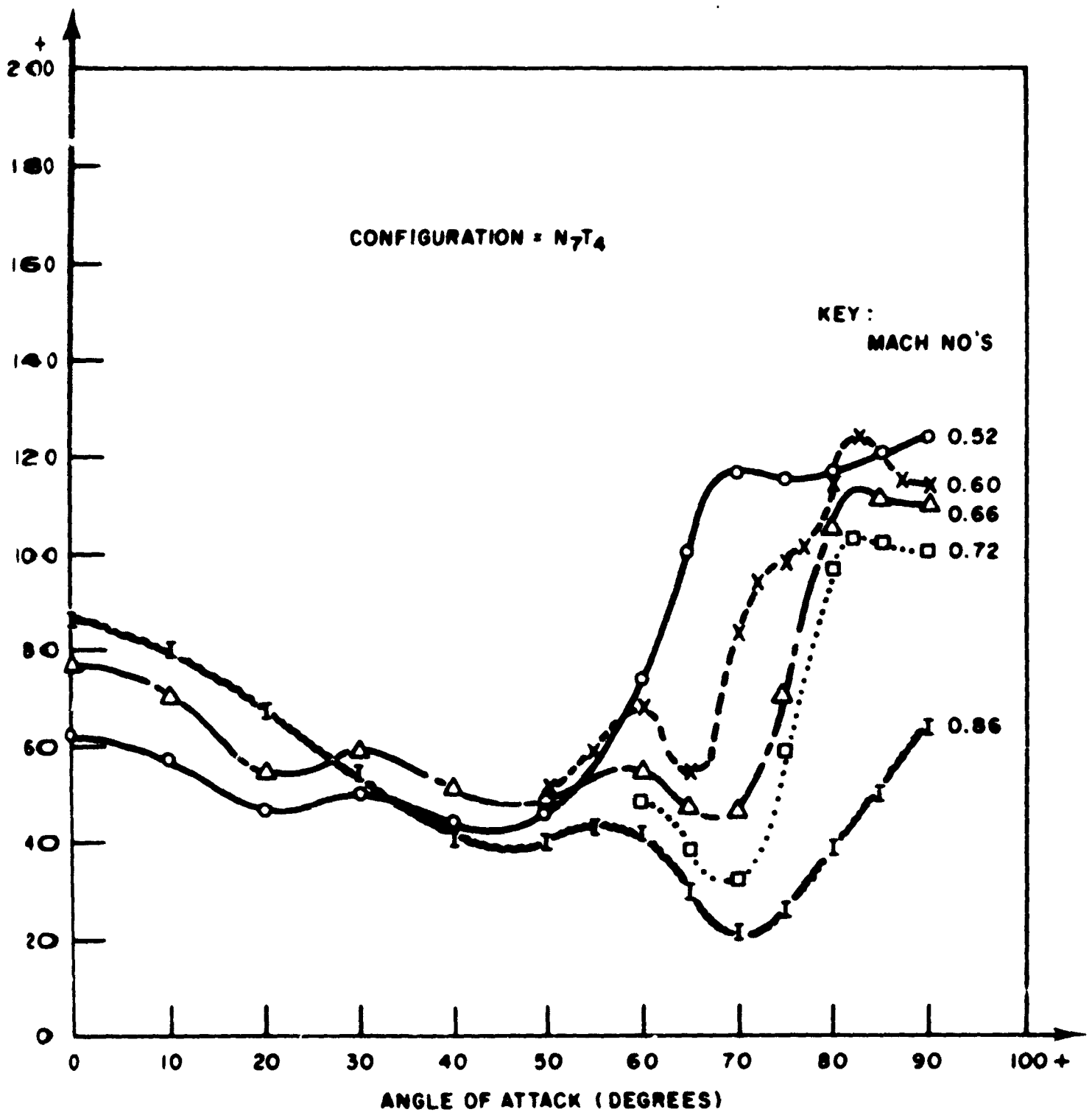

FIG. 6 BASIC FINNER
SPIN RATE VS ANGLE OF ATTACK

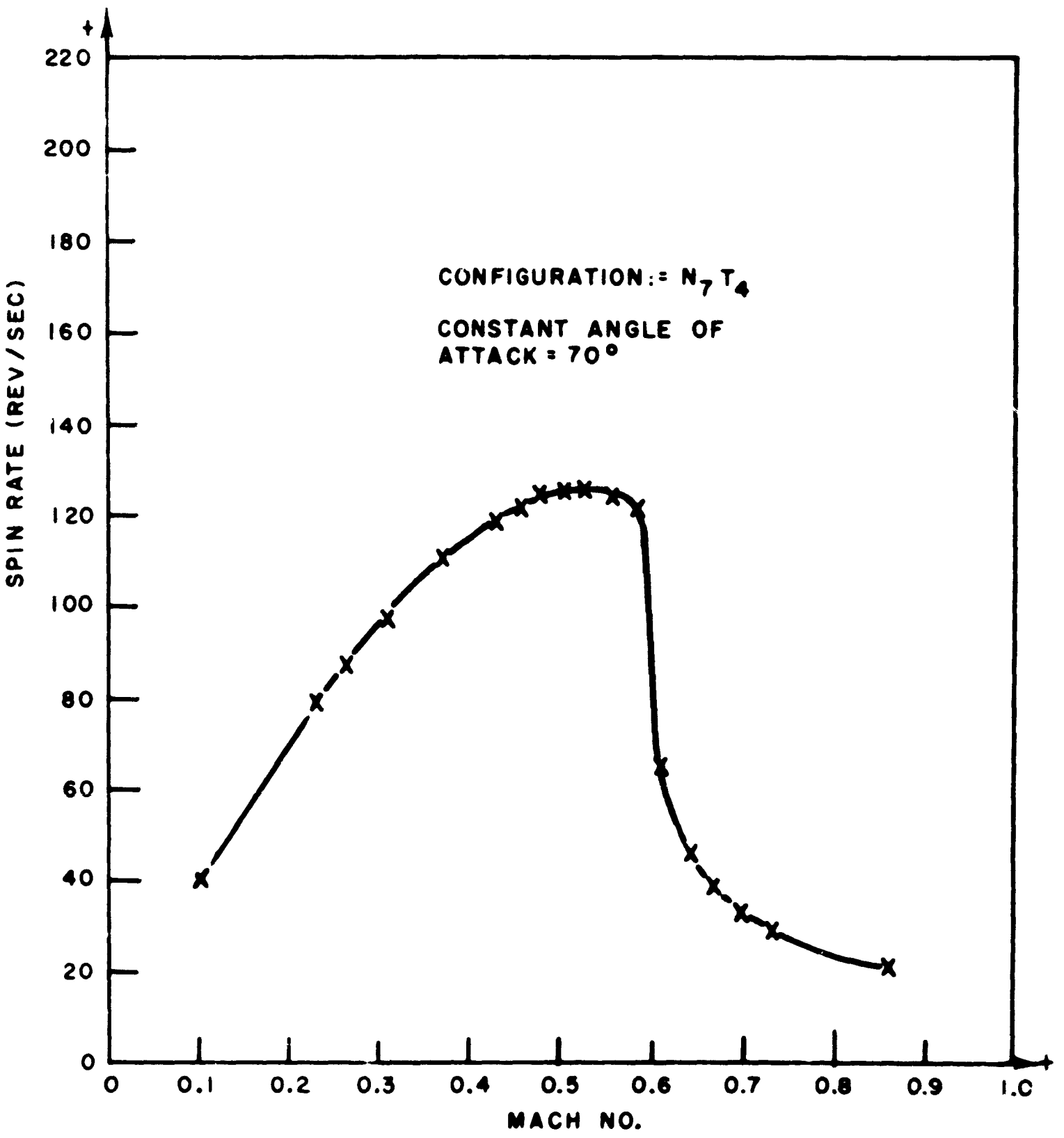

FIG. 7 BASIC FINNER
SPIN RATE VS. MACH NUMBER

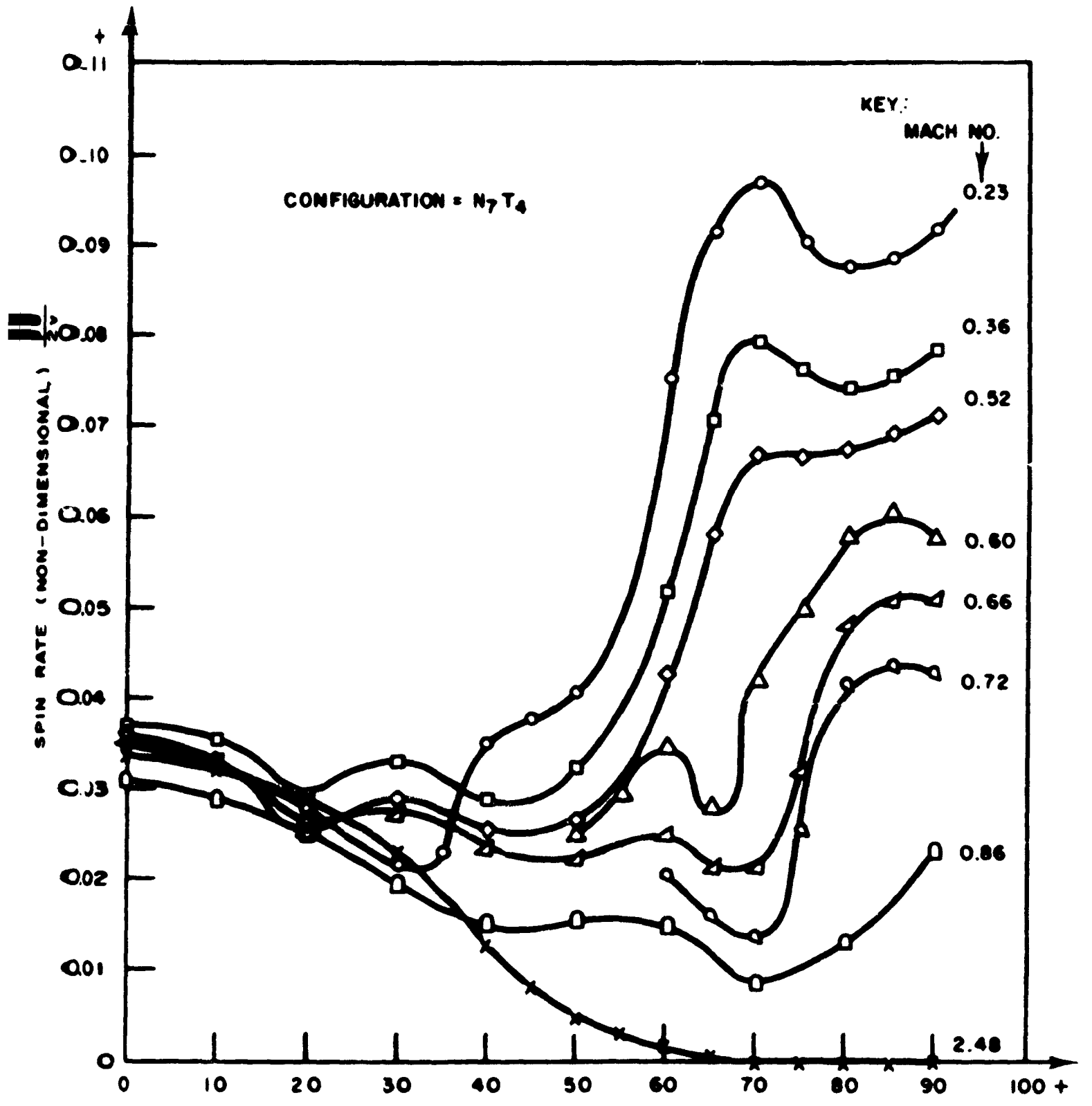

FIG. 8 BASIC FINNER
SPIN RATE VS ANGLE OF ATTACK

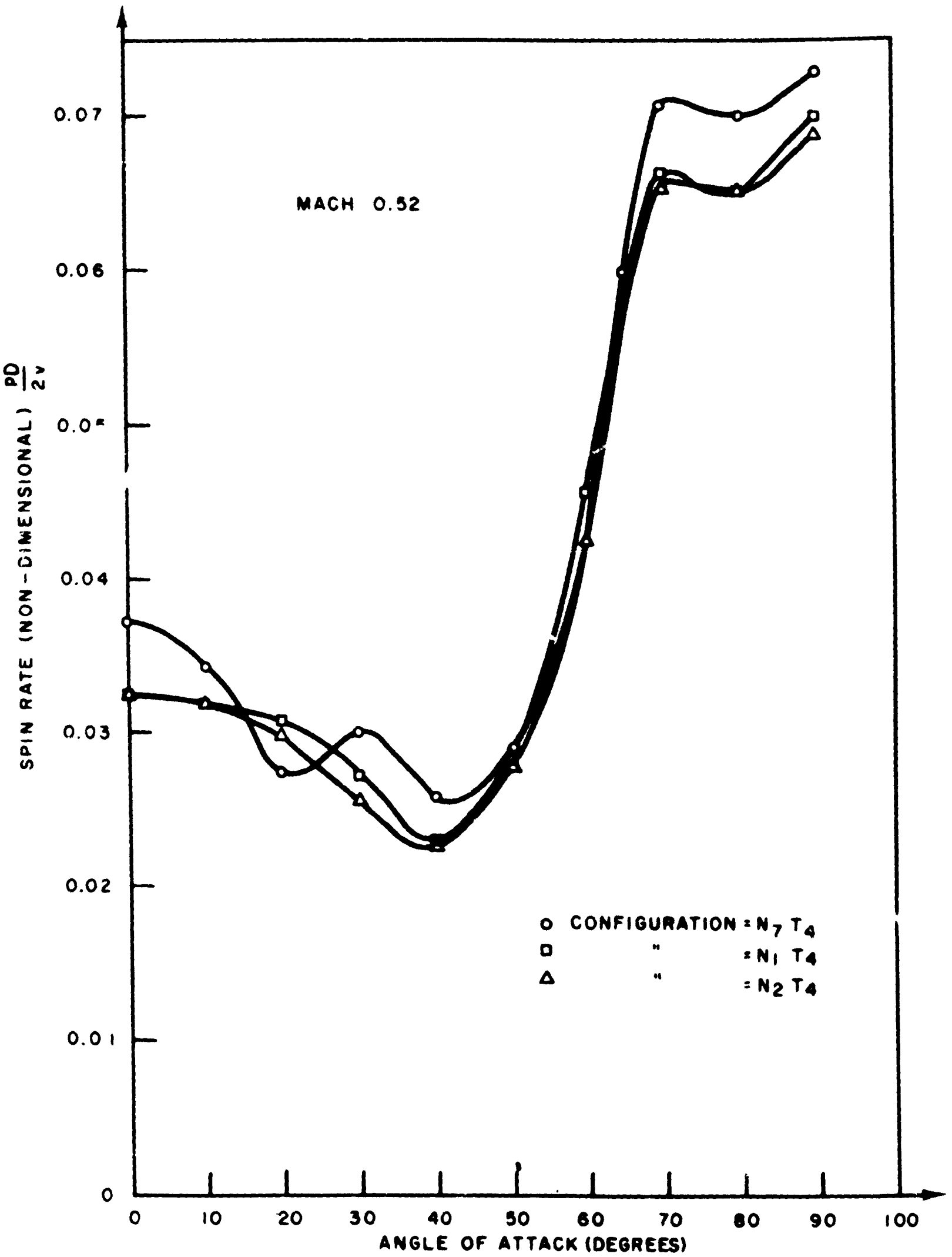

FIG. 9 BASIC FINNER
SPIN RATE VS ANGLE OF ATTACK

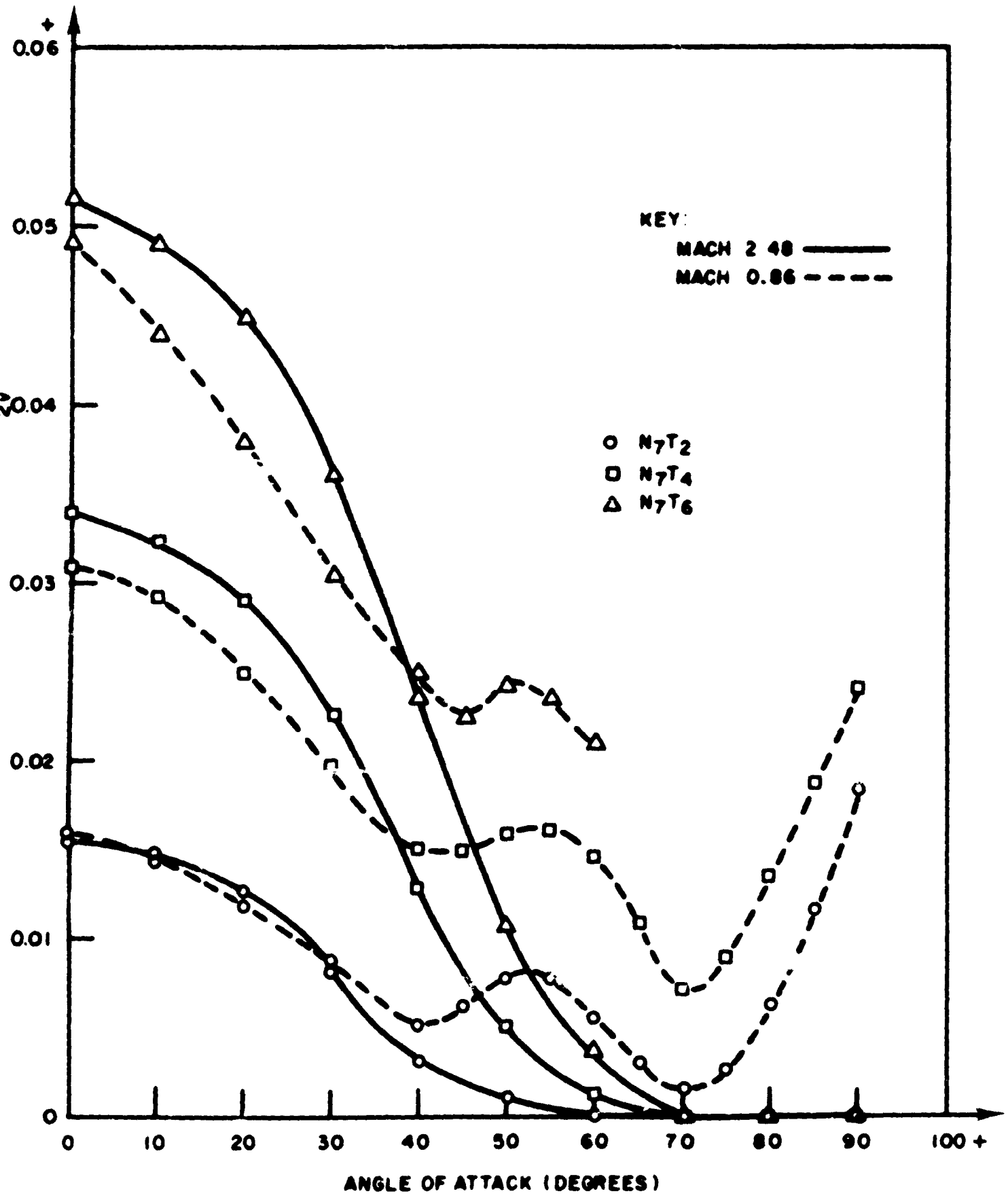

FIG. 10 BASIC FINNER

SPIN RATE VS ANGLE OF ATTACK

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